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THE TERTIARY AND PLEISTOCENE FORAMINIFERA
OF THE MIDDLE ATLANTIC SLOPE

BY

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PREFATORY NOTE.

The investigations carried on in the preparation of this report have yielded fifty-six different species of Foraminifera. Twenty-five of these are from the Eocene, thirty-four are from the Miocene while the Pleistocene has furnished only four. In the above list are included a number of species which have been identified in greensand samples from deep artesian well borings made recently at Norfolk, Virginia, and at Crisfield, Maryland. Most of the species from these borings are undoubtedly from beds of Miocene age but some may belong to some other horizon. The Eocene specimens were nearly all obtained by the writer from the greensand marls of the Pamunkey river and Woodstock, Virginia, though a few were obtained at Marlboro, Maryland.

With the exception of *Cyclammina placenta* Reuss, which came from New Jersey the Miocene forms came from the classic localities of Yorktown and James river, Virginia, and from St. Mary's, Plum Point and Jones Wharf, Maryland.

The author is under obligation to Mr. Lewis Woolman of Philadelphia for the material from the artesian well at Crisfield and to Mr. N. H. Darton of the United States Geological Survey for the samples from Norfolk. Prof. W. B. Clark kindly gave me the interesting specimens of *Cyclammina* from New Jersey.

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INTRODUCTION.

The material investigated from the Eocene marl beds of the Pamunkey river and Woodstock, Virginia, by the author, led to the discovery of twenty-three different species of Foraminifera, a classified list of which was published in Johns Hopkins University Circulars, vol. xv, 1895, p. 6, and again in Professor W. B. Clark's report* on the Eocene Deposits of the Middle Atlantic Slope in Delaware, Maryland, and Virginia. Later studies on Miocene deposits of several localities in Maryland and Virginia and from the Pleistocene beds at Cornfield Harbor, Maryland, resulted in the determination of a large number of genera and species. The presence of so many microscopic organisms proves how favorable were the conditions for their existence when these formations were being laid down.

HISTORICAL SUMMARY.

The first description of Foraminifera from the Miocene of Maryland appears to have been made by Isaac Lea in his Contributions to Geology. This work, published in 1833, contains an article entitled "Description of six new Species of Fossil Shells from the Tertiary of Maryland and New Jersey," which was read before the American Philosophical Society, November 1, 1833.

One of the forms, *Miliola marylandica*, described on pages 215 and 216, and figured on plate VI, fig. 227, represents a smooth *Milioline* shell of three visible segments. This form is undoubtedly identical with *Miliolina seminulum* (Linné), and is so considered in this report.

Prof. J. W. Bailey† in 1845 figures two *Rotaline* casts, one from the greensand of Fort Washington, Maryland, the other from Virginia, but the horizon from which they were obtained is unknown. As both Eocene and Cretaceous occur at Fort Washington the specimen found there could belong to either horizon, though it is more probable that it came from the Eocene greensand.

*Bul. U. S. Geol. Surv., No. 141, pp. 91-92, 1896.

†Am. Jr. Sci., vol. xlviii, pp. 321-343, pl. iv, 1845.

In the Journal of the New York Microscopical Society for April 1887, Mr. Anthony Woodward gives a list of species which he identified in some Miocene sand enclosed in a *Pectunculus* shell from Petersburg, Virginia. This shell had lain undisturbed for many years and when examined yielded twenty-one different species of *Foraminifera*. The following year in Otto Meyer's Report* upon Upper Tertiary Invertebrates from the west side of Chesapeake bay, Mr. Woodward mentions three species; *Miliolina seminulum* (Linné), *Gaudryina pupoides* d'Orbigny, and *Polymorphina compressa* d'Orbigny. The latter I found to be very abundant and wide-spread, occurring in many localities and it is present in both Eocene and Miocene deposits.

In the reports upon the artesian well borings of New Jersey made during the last few years Mr. Lewis Woolman of Philadelphia has recognized the presence of Foraminifera many times but so far as I am aware he has not determined the various species observed. It is probable that these samples from the well borings will furnish a number of species when systematically studied, especially those of the Miocene age.

This seems to be all that has been done upon the Foraminifera of the Middle Atlantic Slope up to the present time. Nearly all species previously recognised have been identified by the writer and many forms are here described for the first time from the Atlantic Slope Tertiary. Two forms are believed to be new. One, *Spirillina orbicularis*, is from the Miocene beds of Yorktown, Virginia; the other, *Spiroplecta clarki*, is from the Eocene of Woodstock, Virginia. Until the discovery of the genus *Spiroplecta* by the author in the Virginia Eocene this was unknown in deposits of Tertiary age although it was known in the Cretaceous and is found in existing oceans.

LITHOLOGICAL CHARACTER OF THE DEPOSITS.

The mineral glauconite plays an important part in the Eocene formation of the Middle Atlantic Slope and in some localities constitutes almost the entire bed. This greensand is often argillaceous and constitutes with the shell material present a true marl, which in many places is so indurated as to form limestone bands. This feature is well illustrated on the Potomac river at the mouth of Aquia creek, Virginia where

*Proc. Acad. Nat. Sci. Phila., 1888, pp. 170-171.

the huge boulders from the lower indurated layers lie scattered along the beach. The same is also seen at Fort Washington, Piscataway creek, Henson branch, Marlboro, Maryland, and at other places. Where the glauconite has weathered the characteristic bluish-green color is changed to a light gray or reddish-brown, which from the large amount of iron present is often cemented into a ferruginous sandstone. This is particularly well illustrated in the bluffs along the Severn river. The land-derived element which is present in addition to the argillaceous material is chiefly quartz, together with some mica and sometimes these materials predominate forming beds of gray sands or sandy clays.

Prof. W. B. Clark mentions the occurrence of a coarse pebble bed which has been found in some localities at the base of the formation. The following chemical analyses taken from Prof. Clark's Report above mentioned serve well to show the composition of the greensand.

Analyses of Marls.

	Woodstock, Va.	Evergreen, Va.	Aquia Creek, Va.	Winchester Md.
H ₂ O at 110°.....	3.58	3.11	0.76	1.31
Volatile at red heat				
less CO ₂	2.84	2.60	.21	6.27
Al ₂ O ₃ & Fe ₂ O ₃ *.....	22.68	21.50	7.70	41.25
CaO.....	1.66	2.50	36.78	None
MgO.....	2.77	2.06	1.05	.76
K ₂ O.....	.77	.61	.37	.39
Na ₂ O.....	.23	.31	.59	.42
SiO ₂	60.87	63.94	21.58	49.08
CO ₂	3.17	3.53	29.79	.55
P ₂ O ₅	None	None	.09	.13
	98.57	100.16	98.92	100.16
Silicious matter.....	73.48	75.85	25.36	52.30

*A considerable Fe₂O₃ in all samples.

While the Eocene is more or less homogeneous throughout its whole extent the Miocene shows marked variation in its

lithologic character. In New Jersey the lower portion of this formation overlying the marl beds consists of a black micaceous sandy clay often rich in organic matter and is commonly termed "rotten-stone." Near the base of the formation glauconite occurs more or less sparingly dispersed owing to the transgression of the Miocene sea upon the marl beds. Where the Eocene is absent the writer has found this sandy clay filled with casts of small Panopæas and other Miocene shells directly above the Lime-sands of the Rancocas formation. A good illustration of this is seen in the bank by the mill-pond at Harrisonville, Gloucester county, New Jersey.

Overlying this dark sandy clay are fine micaceous sands pinkish or yellowish in color, the character of which is best described by the words, fluffy or mealy. In some places this sand carries enough argillaceous material to serve as a moulding sand and is so used by Mr. Wilson who ships it to Philadelphia from his pits not far from Harrisonville. The famous glass sands of New Jersey belong to this period. In some cases the sand has become consolidated so completely as to form a veritable quartzite as is seen in the pits of Gilbert A. Ayre near Marlboro, Cumberland county, N. J. The marl beds so largely worked in Cumberland county while exceedingly rich in Mollusca seem to be without Foraminifera, at least the author has found none in the material examined. That they are present in many of the Miocene clays has been proven by the well-borings.

In Maryland and Virginia the Miocene has a wide representation and consists of clays, sands, and shell marl. The clays are often developed in lenticular bands as is seen in the bluffs by Yorktown. This clay in that vicinity yields a number of Foraminifera belonging to the *Miliolidae* which indicate a warm climate. The great thickness of Infusorial earth developed in Maryland and Virginia must be mentioned although the fossils found in it belong to other microscopic groups.

The Pleistocene Foraminifera from Cornfield Harbor, Maryland, occur in a deposit of shell marl not unlike that which characterizes the Miocene. There are a large number of forms present in this deposit but they are limited to four or five genera of which the genus *Polystomella* plays the most important part. That the deposits were formed in shallow water throughout the Tertiary period seems abundantly proven by the great abund-

ance of *Pulvinulina elegans* d'Orbigny, in the Eocene, and the absence of its relative, *Pulvinulina partschiana* d'Orbigny, a deep water species, by the presence in the Miocene of such species as *Rotalia beccarii* (Linné), *Nonionina depressula* (Walker & Jacob), and in the Pleistocene by the abundance of *Polystomella striato-puncta* (Fichtel & Moll).

The bibliography herein given contains a list of the literature which has been most helpful in the preparation of this report and is intended to include nearly everything which has been published on American Tertiary Foraminifera. Only a limited number of the most useful European works are cited here.

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——— In Otto Meyer's On Invertebrates from the Eocene of Mississippi and Alabama.

Proc. Acad. Nat. Sci. Phila., pp. 51-6, 1887.

DESCRIPTION OF SPECIES.

PROTOZOA.**Rhizopoda.****FORAMINIFERA.****Cyclammina placenta.**

Syn. *Nonionina placenta* Reuss, Zeitsch. deutsch. geol. Gesell, 1851, p. 72, pl. v, fig. 33.

Halophragmium placenta, Andreae, Beitrag zur Kent. Elsass. Tertiars, Theil ii, p. 105, pl. vii, fig. 6, 1884.

Test large, discoidal, compressed, of a snow white color, consisting of numerous irregular chambers, about fifteen in the final convolution; peripheral margin somewhat lobulated, septal lines distinct, slightly depressed, irregularly curved; peripheral margin rounded; septal plane rather large, ovoidal; diam. 3.10 mm.

Horizon and Locality.—Miocene, near Mullica Hill, N. J.

Geological distribution.—Oligocene, and Miocene.

In the description of the above genus by Prof. H. B. Brady in the Challenger Report, vol. ix, p. 351, the author states that *Cyclammina* is unknown in the fossil state, but there can be no longer any doubt about its occurrence in deposits of middle Tertiary age. The finely arenaceo-silicious test unaffected by acids, its peculiar complex structure, and its shape, make it easily recognized.

Textularia abbreviata.

Syn. *Textularia abbreviata* d'Orbigny, Foram. Foss. Vien., p. 249, pl. xv, figs. 9-12 (error for 7-12), 1846.

Test short and thick, sharply pointed at the posterior end, rapidly enlarging above, laterally compressed but not strongly so being broadly elliptical in outline with narrowly rounded margins approaching angularity. The chambers are narrow and increase in size rapidly towards the ultimate chamber; septal lines straight; apparent as fine lines; aperture a semilunar arch on the interior margin of the final segment.

Horizon and locality.—Miocene; James river, Va.

Geological distribution.—Tertiary.

The genus *Textularia* is represented by several species in the James River Miocene. The material from which the Foraminifera were extracted came from the bluffs at Grove's Landing.

Textularia agglutinans.

Syn. *Textularia agglutinans* d'Orbigny, Foram. Cuba, p. 136, pl. 1, figs. 17, 18, 32-34, 1839.

Textularia agglutinans Brady, Chal. Rep't, vol. ix, p. 363, pl. xliii, figs. 1-3, var. figs. 4 and 12, 1884.

Test agglutinous, elongated, tapering only slightly, of a dull gray color, convex laterally, peripheral margin lobulated, rounded, chambers numerous, nine or ten in each series, septa somewhat curved, short. Length 1.10 mm.

Horizon and locality.—Miocene; Plum Point, Md. Not common.

Geological distribution.—Cretaceous to Recent.

Textularia articulata.

Syn. *Textularia articulata* d'Orbigny, Foram. Foss. Vien., p. 250, pl. xv, figs. 16-18, 1846.

Test broad, laterally compressed, tapering only slightly toward the posterior end which is slightly rounded; peripheral margin sharp and provided with a marginal keel encircling the sides of the whole shell; chambers numerous, about ten in each series, separated by straight or only slightly curved septa; aperture a small median opening along the inner margin of the final segment; length 0.65-0.86 mm.

The above species is closely allied to *Textularia carinata* d'Orbigny but differs in the absence of marginal irregularities and spines, and the sutures are not quite as limbate.

Horizon and locality.—Miocene; Plum Point, Md.

Geological distribution.—Middle and Upper Tertiary.

Textularia gramen.

Syn. *Textularia gramen* d'Orbigny, Foram. Foss. Vien., p. 248, pl. xv, figs. 4, 6, 1846.

Textularia gramen Brady, Chal. Rep't, vol. ix, p. 365, pl. xliii, figs. 9, 10, 1884.

Test arenaceous, rough, stoutly built, laterally compressed, margin subangular, five to seven wide chambers in each series, very slightly convex, posterior end neatly rounded, general out-

line very similar to *Textularia hauerii* d'Orbigny, but separated from that species by its more angular lateral edges, and differing from *Textularia abbreviata* d'Orbigny, which it also resembles, in being less short and thick; length, .50-.78 mm.

The above species is quite common in the Miocene of Virginia.

Horizon and locality.—Miocene; James river and Yorktown, Va.

Geological distribution.—Cretaceous to Recent.

***Textularia sagittula*.**

Syn. *Textularia sagittula* DeFrance, Dict. Sci. Hist., vol. xxxii, p. 177; vol. liii, p. 344; Atlas Conch., pl. xiii, fig. 5, 1824

Textularia sagittula Brady, Chal. Rep't, vol. ix., p. 361, pl. xlii, figs. 17, 18, 1884.

Test elongated, strongly compressed with sharp-angled peripheral margins; chambers numerous, closely set, separated by short, straight septal lines visible externally; aperture linear; length 0.69-1.10 mm.

Horizon and locality.—Eocene; Marlboro, Md.

Miocene; James river, Va.; Plum Point, Md.

Geological distribution.—Cretaceous to Recent.

***Textularia subangulata*.**

Syn. *Textularia subangulata* d'Orbigny, Foram. Foss. Vien., p. 274, pl. xv, figs. 1-3, 1846.

Test consisting of a relatively small number of chambers which increase very rapidly in size from the posterior to the anterior end; peripheral margins sharp-angled. The sides of the shell are laterally compressed and parallel, only their extremities forming the sharp-angled periphery; posterior end acuminate, anterior broad and obtusely rounded; ultimate chamber much elevated and larger than any other segment; aperture an arched median slit along the inner margin of the final segment; length 1.0 mm.

Horizon and locality.—Miocene; James river, Va.

Geological distribution.—Tertiary.

***Spiroplecta clarki*.**

Syn. *Spiroplecta clarki* Baggs, Johns Hopkins Univ. Circulars, vol. xv, p. 5, 1895.

Test elongate, textulariform, finely arenaceous, firmly cemented; compressed strongly, lateral margins sharp and very slightly lobed; surface of shell rough, of a dull gray color; chambers at first planospiral then arranged biserially with nine and

ten respectively on each side; aperture a median arched opening; length 0.53 mm., breadth 0.20 mm.

The occurrence of *Spiroplecta* has never been reported from the Tertiary formation, save in the present instance, so far as I am able to learn. It has, however, been described from the Cretaceous of Mississippi and from the Gault and Chalk of England (Parker & Jones), and is sparingly found in present oceans (Brady). It has also been reported from the Post-tertiary beds of the northeast of Ireland (Wright).

The above specimens which have been identified as belonging to the genus *Spiroplecta* seem to be new. They more nearly resemble *Spiroplecta biformis* Parker & Jones, but differ from that species in the possession of sharp angular edges. The distal end is more obtusely rounded than in Textularian types and the chambers are less regularly developed. Only two specimens have thus far been discovered.

Horizon and locality.—Eocene; Woodstock, Va.

Geological distribution.—Eocene.

Genus *BULIMINA* d'Orbigny.

Bulimina aculeata.

Syn. *Bulimina aculeata* d'Orbigny, Ann. Sci. Nat., vol. vii, p. 269. No. 7, 1826.

Bulimina aculeata Brady, Chal. Rep't, vol. ix, p. 406, pl. li, figs. 7-9, 1884.

Test composed of numerous irregular sized chambers arranged in a short triserial spire; anterior end obtusely rounded and free from surface ornamentation, posterior ending rather bluntly and furnished with spines, the lower chambers also have spines and irregular ridges more or less developed; length .60 mm.

This is not a common form in the Virginia Miocene. Its peculiar surface ornamentation makes it easy to identify.

Horizon and locality.—Miocene; James river, Va.

Geological distribution.—Miocene.

Bulimina buchiana.

Syn. *Bulimina buchiana* d'Orbigny, Foram. Foss. Vien. p. 186, pl. xi, figs. 15-18, 1846.

Bulimina buchiana Brady, Chal. Rep't, vol. ix, p. 407, pl. li, figs. 18, 19, 1884.

Test short and stout, triserial, tapering; posterior end acutely rounded, anterior obtuse; segments distinct, slightly inflated; surface of shell marked by definite longitudinal costæ, which

extend from the posterior to near the central portion of the final segments. Aperture an elongated slit near the lower portion of the septal plane; length variable.

Prof. H. B. Brady considers that this form occupies an intermediate position between *Bulimina inflata* and *Bulimina rostrata*, but the costæ of the former are short and extend into stout spines beyond the margin of the chambers, while the costæ of *Bulimina rostrata* are continuous and cover almost the whole test and the segments are either indistinct or entirely concealed.

This species is very common at a depth of 645 feet in the well boring at Norfolk, Va.

Horizon and locality.—Miocene; Norfolk, Va., common in well borings, depth 645 to 695 feet.

Geological distribution.—Eocene to Recent.

***Bulimina elongata*.**

Syn. *Bulimina elongata* d'Orbigny, Foram. Foss. Vien., p. 187, pl. xi, figs. 19, 20, 1846.

Test very much attenuated though tapering but slightly from end to end; segments short, oval, somewhat irregularly arranged and lobulated at the margins, not smooth as in *Bulimina imbricata* Reuss, which it somewhat resembles; primordial end sharply, anterior obtusely rounded; chambers numerous, of irregular size and separated by depressed septa; ultimate chamber provided on its septal face with a comma-shaped aperture; length 0.37 mm,

Horizon and locality.—Miocene; Plum Point, Md., rare.

Geological distribution.—Lower Tertiary to Recent.

Genus *SPIROLOCULINA* d'Orbigny.

***Spiroloculina planulata*.**

Syn. *Miliolites planulata* Lamarck, Ann. du Museum, vol. v, p. 352, No. 4, 1805.; Anim. sans Vert., vol. vii, p. 613, No. 4, 1822.

Spiroloculina planulata Brady, Chal. Rep't, vol. ix, p. 148, pl. ix, fig. 2, a, b, 1884.

Test free, calcareous, imperforate, oval, complanate, and only slightly depressed at the center; chambers smooth, compressed, placed alternately on opposite sides of the shell. The peripheral margins are gently rounded. The aperture is in the form of a narrow high arched or horse-shoe shaped opening with a projecting tongue at the lower margin; length 0.90 mm, breadth 0.60 mm.

I have only one specimen of this interesting species. According to Prof. H. B. Brady, recent specimens of this form are found

abundantly on the shores of the British Isles, and in temperate seas it has a wide distribution but it is unknown in the cold water of arctic latitudes.

Horizon and locality —Miocene; Yorktown, Va.

Geological distribution.—Lower Lias? Tertiary and Recent.

Genus *MILIOLINA* Williamson.

***Miliolina seminulum*.**

Syn. *Serpula seminulum* Linne, Syst. Nat., 12 ed., p. 1264, No. 791, 1767; 13 ed. (Gmelin's), p. 3739, No. 2, 1788.

Miliolina seminulum Williamson, Rec. Foram. Gt. Brit., p. 85, pl. vii; figs. 183-185, 1858.

Miliolina seminulum Brady, Chal. Rep't, vol. ix, p. 157, pl. v, fig. 6, a, b, c, 1884.

Test free, calcareous, imperforate, elliptical or oblong in outline, consisting of five visible, elongated, smooth segments.

The segments are arranged in an inequilateral way about a *Milioline* axis. The two outer ones extending the whole length of the shell with their ends overlapping and the aperture a horse shoe-shaped opening, placed in the end of the larger segment.

This species of *Miliolina* was first recognized in the Miocene of St Mary's, Maryland, by Isaac Lea and was described by him under the name *Miliola marylandica* in his Contributions to Geology, 1833, pp. 215, 216, pl. 6, fig. 227, as follows:—"Shell elliptical, depressed in the middle, rounded at the edges, lobes in contact; mouth small, round, terminal, furnished with a large tooth".

In the above description of Mr. Lea no reference is made to the smooth character of the shell or to the number of segments but his figure indicates a smooth form with three segments upon one side and is undoubtedly to be referred to the species *Miliolina seminulum* Linné; length 0.60-0.74 mm., breadth 0.30-0.47 mm.

Horizon and locality.—Miocene; Yorktown, James river, Va.; Jones Wharf, St. Mary's, Md.

Geological distribution.—Eocene to Recent.

Genus *LAGENA* Walker and Boys.

***Lagena globosa*.**

Syn. *Vermiculum globosum* Montagu, Test. Brit., p. 523, 1803.

Lagena globosa, Brady, Chal. Rep't., vol. ix, p. 452, pl. lvi, figs. 1, 2, 3, 1884.

Test subglobular, elliptical or pyriform, smooth, anterior mar-

gin somewhat projecting; cell walls thin, hyaline, aperture in an entosolenian neck; length 2.00 mm., breadth 1.50 mm.

Horizon and Locality.—Pleistocene; Cornfield Harbor, Md.
Not common.

Genus *NODOSARIA* Lamarck.

***Nodosaria aculeata*.**

Syn. *Nodosaria aculeata* d'Orbigny, Foram. Foss. Vien., p. 35, pl. 1, figs. 26, 27, 1846.

Test rather small, short and stoutly built; primordial end bluntly rounded, anterior large and bulbous, prolonged into a tubular neck which carries the aperture; segments five in number, short, only slightly constricted, surface very thickly covered with spines which project straight out, or nearly so, from the surface.

This interesting species should perhaps be considered as identical with *Nodosaria hispida* d'Orbigny, but typical forms of the latter are always deeply constricted at the nodes and sometimes the chambers are entirely separated and are then connected by stoloniferous tubes, while the segments of *Nodosaria aculeata* are almost flush at the sutures.

Horizon and locality.—Miocene; Norfolk, Va. Well boring, depth 665 feet.

***Nodosaria affinis*.**

Syn. *Nodosaria affinis* d'Orbigny, Foram. Foss. Vien., p. 39, pl. 1, figs. 36-39, 1846.

Nodosaria affinis Sherborn and Chapman, Jour. Roy. Microsc. Soc., ser. 2, vol. vi, p. 748, pl. xiv, fig. 33, 1886.

Test very large, nearly straight, more tapering than *Nodosaria bacillum* and without having the primordial chamber larger than the succeeding one; proximal end acuminate; chambers numerous, unconstricted below but becoming distinctly so above; surface marked by about ten distinct elevated costæ as in *Nodosaria bacillum*; aperture central, elevated on the ultimate chamber; length 9.00 mm. or more.

Horizon and locality.—Eocene; Woodstock, Va.

Geological distribution.—Tertiary.

***Nodosaria bacillum*.**

Syn. *Nodosaria bacillum* DeFrance, Dict. Sci. Nat., vol. xxxv, p. 127; vol. xxxvi, p. 487, Atlas Conch., pl. xiii, fig. 4, 1825.

Nodosaria bacillum Bagg, Johns Hopkins Univ. Circulars, vol. xv, p. 5, 1895.

Test very large, straight or nearly so, surface marked by about ten very distinct snow-white costæ, though the number does

not remain constant, some specimens having only eight costæ below and as many as twelve above; primordial chamber bulbous, acuminate, though with the spine usually broken; segments regular, less distinct below, marked by straight transverse septa; length, fragments of nine chambers measure five mm.

Horizon and locality.—Eocene; Woodstock, Va.

Geological distribution.—Tertiary.

***Nodosaria communis*.**

Syn. *Dentalina communis* d'Orbigny, Mem. Soc. geol. France, vol. iv, p. 13, pl. 1, fig. 4, 1840.

Nodosaria communis Bagg, Johns Hopkins Univ. Circulars, vol. xv, p. 5, 1895.

Test elongate, smooth, with depressed oblique septa; primordial chamber larger than the one succeeding and in our specimens acuminate; ultimate chamber elongate, tube-like; transverse section circular; aperture round, smooth; length 0.60 mm.

Nodosariae are very rare in the Miocene of Maryland and I have only one specimen of the above species. It possesses but three chambers and is undoubtedly a young form.

Horizon and locality.—Eocene; Sunnyside, Md.

Geological distribution.—Permian to Recent.

***Nodosaria consobrina*, var. *emaciata*.**

Syn. *Nodosaria consobrina* var. *emaciata* Reuss, Denkschr. Akad. Wiss. Wien., vol. xxv, p. 132, pl. ii, figs. 12, 13, 1865.

Test smooth, elongate, tapering, segments numerous, short, elongate-oval; similar to *Nodosaria consobrina* but more elongated and slender; septa somewhat depressed, transverse. The proximal chamber is rounded and ends in a nipple-shaped aperture.

Horizon and locality.—Eocene; Marlboro, Md.

***Nodosaria farcimen*.**

Syn. *Orthoceras farcimen* Soldani, Testaceographia, vol. i, pt. 2, p. 98, pl. cv, fig. o., 1791.

Nodosaria farcimen Brady, Chal. Rep't, vol. ix, p. 498, pl. lxii, figs. 17, 18; (woodcuts, fig. 13, a, b, c.).

Test smooth, arcuate, tapering, with from six to ten inflated segments separated by deep, straight, transverse sutures. The latter feature separates this species from *Nodosaria communis* in which the sutures are oblique. There is also an irregularity in the increase of the size of the chambers noticeable in most specimens. Ultimate chamber prolonged into a round tube which bears the oral opening; length 2.82 mm. (Cretaceous), 1.10 mm. (Eocene).

Specimens of the above species from the Cretaceous of New

Jersey are much larger and show less regularity in the size of the chambers. The small Eocene specimens are not very common.

Horizon and locality.—Eocene; Pamunkey river, Va. .

Geological distribution.—Permian to Recent.

Nodosaria obliqua.

Syn. *Nautilus obliquus* Linne, Syst. Nat., 12 ed., p. 1163, 281, 1767; *ibid*, 13 ed. (Gmelin's), p. 3372, No. 14, 1788.

Nodosaria obliqua Brady, Chal. Rep't, vol. ix, p. 513, pl. lxiv, figs. 20-22, 1884.

Test variable in size, sometimes very large, elongate, tapering, arcuate; septal lines depressed, surface costate, costæ varying in size and number in different specimens; chambers numerous, ventricose, distinct; aperture central, radiate.

The few specimens we have of this species are rather short and stoutly built like *Dentalina confluentis* Reuss, which form they are identical with, the latter being a variety of this exceedingly variable species.

Locality.—Norfolk, Va. Well-boring, depth 685 feet.

Geological distribution.—Lias to Recent.

Genus *VAGINULINA* Lamarck.

Vaginulina legumen.

Syn. *Nautilus legumen* Linne, Syst. Nat., 10th Ed., p. 711, No. 248, 1758; 12th Ed., p. 1164, No. 288, 1767.

Vaginulina legumen Bagg, Johns Hopkins Univ. Circulars, vol. xv, p. 5, 1895.

Test nearly straight, pod-like, compressed, smooth, consisting of only six chambers; septa limbate, parallel, oblique, less distinct towards the distal end; ultimate chamber slightly prolonged at the anterior end; aperture radiate; length 0.80 mm.

Horizon and locality.—Eocene; Sunnyside, Md.

Geological distribution.—Trias to Recent.

Genus *CRISTELLARIA* Lamarck.

Cristellaria cultrata.

Syn. *Robulus cultratus* Montfort, Conch. Syst., vol. i, p. 214, 54 genre, 1808.

Cristellaria cultrata Parker & Jones, Phil. Trans., vol. clv, p. 344, pl. xiii, figs. 17, 18; pl. xvi, fig. 5, 1865.

Test circular, biconvex, smooth and glistening, margin sharp, broadly keeled; chambers seven to eleven, somewhat convex, smooth or costate; aperture radiate.

Cristellaria cultrata is a common form at several localities in the Upper Cretaceous formations of New Jersey. The width

of the marginal keel is very variable though always more or less developed and serves to distinguish this species from *Cristellaria rotulata* which it resembles; geologically it has a wide range, being found as early as the Triassic (Lias) and still existing in present oceans.

Localsty.—Norfolk, Va. Well boring, depth 695 feet.

Crisfield, Md. Well boring, depth 776 feet.

***Cristellaria radiata*.**

Syn. *Robulina radiata* Bornemann, Zeitsch. deutsch. geol. Gesell., vol. vii, p. 334, pl. xv, fig. 1, 1855.

Cristellaria radiata Bagg, Johns Hopkins Univ. Circulars, vol. xv, p. 5, 1895.

Test nearly circular, moderately compressed, with circular, raised umbilicus; final convolution showing ten strongly curved even chambers, marked externally by raised white septal lines which become less distinct towards the peripheral margin; keel quite definite and of the same snow-white color as the raised septa, while the chambers are darker in color and are strongly contrasted with the rest of the shell. The surface is smooth and glistening; the aperture radiate; diameter 1.26 mm.

Horizon and locality.—Eocene; Woodstock, Va., rare.

Geological distribution.—Tertiary.

***Cristellaria rotulata*.**

Syn. *Lenticulites rotulata* Lamarck, Ann. du Museum, vol. v, p. 188, No. 3; Tableau Encyc. et Meth. pl. cccclxvi, fig. 5, 1804.

Cristellaria rotulata Parker & Jones, Phil. Trans., vol. clv, p. 345, pl. xiii, fig. 19, 1865.

Test involute, biconvex, smooth, peripheral margin sharp, non-carinate, chambers numerous, eight or nine in the last convolution; septa moderately curved, visible externally as fine lines; aperture elliptical, radiate.

The genus *Cristellaria* although found so abundantly in the New Jersey Cretaceous seems to be rather rare in the Atlantic Slope Tertiary and is represented by only a few species.

***Cristellaria wetherellii*.**

Syn. *Marginulina wetherellii* Jones, Morris's Cat. Brit. Foss., ed 2, p. 37, 1854.

Cristellaria wetherellii Brady, Chal. Rep't, vol. ix, p. 537, pl. cxiv, fig. 14, 1884.

Test elongate, compressed, pod-like, primordial segments more or less involute, ultimate segments extended into a straight or nearly straight series, surface of shell marked by large tubercles more or less regularly arranged along the septal lines and also upon the chambers of some segments.

Transverse sections are elliptical and show in some forms an angular periphery and when so approaching *Cristellaria decorata* Reuss, in outline. Another closely allied form is seen in *Marginulina hochstetteri* Stache, which has the tubercles developed but lacks the costæ and chamber decoration. Aperture round and situated at the end of a somewhat prolonged neck; length 1.56 mm., breadth 0.50 mm.

This highly ornamented *Cristellaria* was also found by the author in the Cretaceous of New Jersey but it is rare. In the material from the well boring at Crisfield there are many of this species at a depth of 776 feet.

Horizon and locality.—Miocene?; Crisfield, Md. Well boring; depth 776 feet.

Geological distribution.—Cretaceous to Recent.

Genus *POLYMORPHINA* d'Orbigny.

Polymorphina amygdaloides.

Syn. *Polymorphina amygdaloides* Reuss, Sitzungsab. Akad. Wiss. Wien, vol. xviii, p. 250, pl. viii, fig. 84, 1855.

Polymorphina amygdaloides Baggs, Bull. U. S. Geol. Surv., No. 141, p. 91, 1896.

Test ovoid, flatly compressed upon one side, somewhat convex upon the other; anterior end acute, posterior obtusely rounded; chambers three or four elongated, alternating, not all equally depressed, septal lines somewhat depressed, especially the longest. The surface is smooth and glistening; length 0.35 mm.

The above form is not typical for the species, being more unsymmetrical than usual owing to the prominence of one of the lateral chambers. According to Messrs. Brady, Parker and Jones, this species is very variable in form and includes such varieties as *Polymorphina minuta* Rœmer, *Polymorphina guttula* Reuss, *Polymorphina depauperata* Reuss, etc.

Horizon and locality.—Eocene; Pamunkey river, Va.

Geological distribution.—Tertiary to Recent.

Polymorphina austriaca.

Syn. *Guttulina austriaca* d'Orbigny, Foram. Foss. Vien., p. 223, pl. xii, figs. 23-25, 1846.

Polymorphina austriaca Baggs, Johns Hopkins Univ. Circulars, vol. xv, p. 5, 1895.

Test oviform, smooth, moderately compressed, acuminate anteriorly, consisting of four chambers which are oblong, oblique

and somewhat convex, separated by fairly deep sutures; aperture mammillate.

d'Orbigny considers that *Guttulina nitida* is closely related to this species but states that it differs from it in the more elevated chambers. Our specimens are slightly more acute posteriorly than d'Orbigny's figure.

Horizon and locality.—Eocene; Woodstock, Va.

Geological distribution.—Tertiary.

✓ ***Polymorphina communis*.**

Syn. *Guttulina communis* d'Orbigny, Ann. Sci. Nat., vol. vii, p. 266, No. 15, pl. xii, figs. 1-4; Modele, No. 62, 1826.

Polymorphina communis Bagg, Bull. U. S. Geol. Surv., No. 141, p. 92, 1896.

Test irregular ovoidal, or egg-shaped, consisting of four or five distinct segments; anterior extremely acute, posterior obtuse; chambers inflated, elliptical, embracing; surface smooth with distinct septal depressions; aperture mammillate; diam. 0.35 mm.

This species occurs quite abundantly in the New Jersey Cretaceous but the forms are much larger than in the Eocene of Maryland.

Horizon and locality.—Eocene; Woodstock, Va.; Pamunkey river, Va.

Geological distribution.—Lias to Recent.

***Polymorphina complanata*.**

Syn. *Polymorphina complanata* d'Orbigny, Foram. Foss. Vien., p. 234, pl. xiii, figs. 25-30, 1846.

Test complanate, elongate, resembling *Fronicularia* in outline, chambers numerous, arranged biserially; anterior end acute, posterior obtusely rounded, lateral margins rounded, nearly parallel; septal lines depressed, slightly oblique and alternating; chambers somewhat lobed at the margin and elevated but not strongly so; surface smooth; aperture mammillate; length 1.73 mm., breadth 0.50 mm.

Horizon and locality.—Eocene; Pamunkey river, Va.

Geological distribution.—Cretaceous and Tertiary.

✓ ***Polymorphina compressa*.**

Syn. *Polymorphina compressa* d'Orbigny, Foram. Foss. Vien., p. 233, pl. xii, figs. 32-34, 1846.

Polymorphina compressa Brady, Parker and Jones, Trans. Linn. Soc.,

London, vol. xxvii, p. 227, pl. xl, fig. 12, a-f, 1870.

"Shell oblong, inequilateral, compressed, more or less fusiform; chambers numerous, arranged in two unequal series, somewhat inflated; septal lines depressed; surface smooth or faintly striated; aperture variable, usually simple, circular, coronate; sometimes labyrinthic or porous"; length, from one twentieth to one tenth of an inch; (Brady, Parker and Jones, loc. cit.); length 0.82-1.30 mm., breadth 0.43 mm.

This species is very common in the Maryland Miocene beds especially at Plum Point, Jones Wharf, Md., and also occurs in the bluffs on the James river, Va.

Horizon and locality.—Eocene; Woodstock, Va. Miocene; Plum Point, Md., Norfolk, Va. Well boring; depth, 685 feet.

Geological distribution.—Lias to Recent.

Polymorphina elegantissima.

Syn. *Polymorphina elegantissima* Parker & Jones, Phil. Trans., vol. clv, table x, p. 438, 1865.

Polymorphina elegantissima Brady, Parker & Jones, Trans. Linn. Soc., London, vol. xxvii, p. 231, pl xl, fig. 15 a-c, 1870.

Test ovoidal, anterior end acute, posterior obtusely rounded; chambers four or five, elongate, arranged in an inequilateral biserial manner and overlapping in such a way that while one side remains nearly flat the opposite is more or less irregularly vaulted and shows all the chambers in parallel arrangement; final segment broad below, embracing, and bearing the mammillate aperture upon the anterior end. Shell surface smooth, finely perforate; length 0.60 mm., breadth 0.40 mm.

Prof. Brady considers that *Polymorphina problema* var. *deltoidea* Reuss, and *Polymorphina anceps* Reuss, are identical with this species.

Horizon and locality.—Eocene; Woodstock, Va.

Geological distribution.—Eocene to Recent.

Polymorphina gibba.

Syn. *Globulina gibba* d'Orbigny, Foram. Foss, Vien., p. 227, pl. xiii, figs. 13, 14, 1846.

Polymorphina gibba Bagg, Johns Hopkins Univ. Circulars, vol. xv, p. 5, 1895.

Test subglobular, apex slightly produced, base obtusely rounded, consisting of from two to four chambers compactly joined and overlapping. The surface is smooth and unmarked by sept-

al constrictions. Septa are visible as delicate, oblique lines; transverse section nearly circular; aperture mammillate; length 0.35 mm., breadth 0.30 mm.

Specimens of the above species from the Eocene of Maryland are very similar to those from the Navesink formation (lower marl bed) of New Jersey, but the Eocene forms are much smaller. It is not a common species in the Eocene.

Horizon and locality.—Eocene; Woodstock, Va.

Geological distribution.—Jurassic to Recent.

Polymorphina lactea.

Syn. *Serpula lactea* Walker and Jacob, (fide Kanmacher's Ed.), Adams Essays Microsc. p. 634, pl. xiv, fig. 4, 1798.

Polymorphina lactea Brady, Parker and Jones, Trans. Linn. Soc. London, vol. xxvii, p. 213, pl. xxxix, fig. 1, a-c, 1870.

Test ovate or subpyriform, only slightly compressed, consisting of three or four chambers with flush sutures and scarcely distinct septal lines; aperture terminal, radiate; diam. 0.39 mm.

Horizon and locality.—Miocene, Plum Point, Md.

Geological distribution.—Jurassic to Recent. Not common.

Polymorphina praelonga.

Syn. *Polymorphina praelonga* Terquem, Mem. Soc. geol. France, ser. 3, vol. i, p. 39, pls. iii, viii, figs. 20, 21; 1878.

Polymorphina praelonga Bagg, Johns Hopkins Univ. Circulars, vol. xv, p. 5, 1895.

Test elongate-oval, attenuated anteriorly; smooth and glistening, nearly circular in transverse section; three or four slightly raised, elongate chambers, marked by somewhat depressed septa; length 0.79 mm.

This species with its many varieties is beautifully illustrated in Terquem's monograph on the Eocene Foraminifera of Paris. According to that author this species is more abundant in the Eocene, being quite rare in deposits of Pliocene age.

Horizon and locality.—Eocene; Woodstock, Va.

Geological distribution.—Eocene to Pliocene.

Genus UVIGERINA d'Orbigny.

Uvigerina canariensis.

Syn. *Uvigerina canariensis* d'Orbigny, Foram. Canaries, p. 138, pl. 1,

figs. 25-27, 1839.

Uvigerina urnula d'Orbigny, Foram. Foss. Vien., p. 189, pl. xi, figs. 21-22, 1846.

The test of *Uvigerina canariensis* is characterized by its smooth shell although faint indications of costæ are sometimes seen in recent specimens and in the form described by d'Orbigny under the name *Uvigerina urnula* from the Miocene of the Vienna Basin. The shell is in the form of an irregularly built tri-serial spire of various length, and ends in a more or less elongated tube with a flaring aperture.

The segments are more or less globose and distinct, the suture being well marked; length 0.57 mm.

Horizon and locality.—Miocene?; Crisfield, Md. Well boring; depth, 776 feet.

Geological distribution.—Miocene to Recent.

***Uvigerina pygmæa*.**

Syn. *Uvigerina pygmæa* d'Orbigny, Ann. Sci. Nat., vol. vii, p. 269, pl. xii, figs. 8, 9, 1826. Modele, No. 67.

Uvigerina pygmæa Parker and Jones, Phil. Trans., vol. clv, p. 363, pl. xiii, figs. 53-7; xvii, fig. 65, 1865.

Test more or less broadly ovate and stoutly built, with thick shell-wall. The chambers are numerous, large and globose, and are separated by depressed septal lines. The surface is marked by a number of prominent longitudinal costæ which are less numerous and larger than in the longer and more tapering *Uvigerina tenuistriata* Reuss. The primordial end is rounded, the anterior extended into a short tubular neck with a flaring aperture.

This interesting little species occurs very abundantly in the samples of greensand from the well boring at Norfolk, Va., and is not rare in the boring at Crisfield, Md.

Horizon and locality.—Miocene; Norfolk, Va. Well boring; depth, 645 to 685 feet. Occurs also at Crisfield, Md., in a deep artesian well boring.

Geological distribution.—Miocene to Recent.

***Uvigerina tenuistriata*.**

Syn. *Uvigerina tenuistriata* Reuss, Sitzungsab. Akad. Wiss. Wien., vol. lxii, p. 485, pt. 1; von Schlicht, Foram. Septar. Pietzpuhl, pl. xxii, figs. 34-37, 1870.

Test much more finely striate than *Uvigerina pygmæa* and more slender, tapering to a small well rounded end below and gradually increasing in size above. The chambers are not so globose and the septa are not so depressed as in *Uvigerina pygmæa*. Aperture at the end of a flaring tubular neck as in typical *Uvigerina* forms.

The above species is less common than the allied form *Uvigerina pygmæa*.

Horizon and locality.—Miocene; Norfolk, Va. Well boring, depth 645 to 685 feet. It also occurs in the artesian well boring, Crisfield, Md.

Geological distribution.—Upper Oligocene to Recent.

Genus *GLOBIGERINA* d'Orbigny.

Globigerina bulloides.

Syn. *Globigerina bulloides* d'Orbigny, Ann. Sci. Nat., vol. vii, p. 277, No. 1, 1826. Modele's No. 17, (young) and No. 76.

Globigerina bulloides d'Orbigny, Foram. Foss. Vien., p. 163, pl. ix, figs. 4-6, 1846.

Globigerina bulloides Brady, Chal. Rep't, vol. ix, p. 593, pl. lxxvii, and pl. lxxix, figs. 3-7, 1884.

"Test spiral, subtrochoid; superior surface convex, inferior more or less convex but with deeply sunken umbilicus, periphery rounded, lobulated; adult specimens composed of about seven globose segments, of which four form the outer convolution, the aperture of the individual chambers opening independently into the umbilical vestibule; diameter sometimes one fortieth of an inch (0.63 mm.), but oftener much less." (Brady, loc. cit.)

Globigerina bulloides is not an unusual form in the Miocene of Virginia but it is more abundant at Plum Point, Maryland than elsewhere.

Horizon and locality.—Eocene; Woodstock, Va. Miocene; Darlington, S. C., James river and Yorktown, Va., Plum Point, Maryland.

Geological distribution.—Cretaceous to Recent.

Genus *SPIRILLINA* Ehrenberg.

Spirillina orbicularis, n. sp.

Test free, consisting of a non-septate tube coiled in a plano-

spiral manner and forming in our specimen about seven convolutions. The peripheral margin is broadly rounded. The lateral surfaces are unlike, upon one the inner side of the coils are marked by a large number of elliptical pits while the opposite is somewhat granulated and apparently without the depressions. The final convolution ends in a constricted aperture, slightly eccentric; diam. 0.52 mm.

The above species resembles *Spirillina margaritifera* Williamson with this difference that in place of tubercles we have depressions. I have only one specimen of this interesting form but it is perfect and I have no hesitation in pronouncing it to be new.

Horizon and locality.—Miocene; Yorktown, Va.

Genus *DISCORBINA* Parker & Jones.

***Discorbina bertheloti*.**

Syn. *Rosalina bertheloti* d'Orbigny, Foram. Canaries, p. 135, pl. 1, figs. 28-30, 1839.

Discorbina bertheloti Bagge, Bull. U. S. Geol. Surv., No. 141, p. 92.

Test very compressed, carinate, finely punctate; spiral side approximately flat, reverse side low-convex; chambers depressed, convex, numerous, margins slightly limbate; ultimate chamber larger than the one preceding. The shell is quite similar to *Truncatulina lobaluta*, but it is more depressed and the walls are more finely perforate; diam. 0.42 mm.

Horizon and locality.—Eocene; Woodstock, Va.

Geological distribution.—Cretaceous to Recent.

***Discorbina orbicularis*.**

Syn. *Rosalina orbicularis* Terquem, Anim. sur la Plage de Dunkerque, pt. 2, p. 75, pl. ix, fig. 4, a, b, 1876.

Discorbina orbicularis Brady, Chal. Rep't, vol. ix, p. 647, pl. lxxxviii, figs. 4-8, 1884.

Test small, nearly circular, superior side convex, inferior depressed at the umbilicus and slightly concave; peripheral margin sharp.

The superior chamber shows numerous, very much elongated chambers which extend nearly half way around the shell as they reach the peripheral margin. Upon the inferior side only three or four segments are visible and these are marked by

very slight septal depressions. The aperture is in the form of an elongated slit reaching from the margin to near the umbilicus upon the inferior surface.

Diam., 0.39.

I have only one specimen of this minute shell.

Horizon and locality.—Miocene; Darlington, S. C.

Geological distribution.—Miocene to Recent.

Genus *TRUNCATULINA* d'Orbigny.

Truncatulina haidingerii

Syn. *Rotalina haidingerii* d'Orbigny, 1846, *Foram. Foss. Vien.*, p. 154, pl. vii, figs. 7-9.

Rotalina ehrenbergii Bailey, *Smithsonian Contrib. to Knowl.*, vol. II, Art. 3, p. 10, figs. 11-13, 1851.

Truncatulina haidingerii Brady, *Chal. Rep.*, vol. ix, p. 663, pl. xcvi, fig. 7, a-c, 1884.

Test circular, biconvex, trochoid, composed of three volutions. Upon the inferior side the chambers are marked by nearly straight somewhat depressed septa, while upon the superior side the septa are more or less curved backward, often quite strongly so. The aperture is in the form of a very small slit near the periphery.

This species is very similar to *Truncatulina ungeriana* but differs from it in being more vaulted and less depressed at the umbilicus. There is no distinct groove following the whorls upon the superior side and the perforations are much smaller than in its allied form.

Our forms of this species from the well boring at Norfolk, Va., found at a depth of 685 feet are of Tertiary age (lower?) and are identical with *Rotalia propinqua* Reuss, which must be considered as a synonym of *Truncatulina haidingerii* d'Orbigny.

Horizon and locality.—Norfolk, Va. Well boring, depth 685 feet.

Geological distribution.—Cretaceous to Recent.

Truncatulina lobatula.

Syn. *Nautilus lobatulus* Walker & Jacob, 1798, (fide Karmacher's Ed.) *Adams Essays Microsc.*, p. 642, pl. xiv, fig. 36.

Truncatulina lobatula Brady, *Chal. Rept.*, vol. ix, p. 660, pl. xcii, fig. 10, pl. xciii, figs. 1, 4, 5; pl. cxv, figs. 4, 5, 1884.

Test plano-convex, moderately vaulted; last volution consisting of seven, eight, or nine chambers with slightly depressed

septa; septal lines being more curved on the superior surface. Aperture a small neatly shaped arch at the inferior margin of the ultimate segment.

Diameter, 0. 6 mm.

The above species shows great variation. Professor Brady considers that the more convex varieties merge into *Truncatulina refulgens*, while flattened forms resemble *Truncatulina wuellerstorfi*. The regularly built convex varieties constitute the *Truncatulina boueana* d'Orbigny, while the less regular are equivalent to *Truncatulina variabilis* of the same author. The latter species is well represented in the very irregular wide spreading forms from Plum Point, Md.

Horizon and locality.—Eocene; Woodstock, Va.; Miocene; James River, Yorktown, and Norfolk, Va.; Plum Point, and Jones Wharf, Md.

***Truncatulina variabilis*.**

Syn. *Truncatulina variabilis* d'Orbigny, Ann. Sci. Nat., vol. VII, p. 279, No. 8, 1826.

Truncatulina variabilis Terquem, Mim. Soc. Geol. France, ser. 3, vol. II, Mem. III, p. 1, figs, 18-25, 1878.

Test consisting of a depresssd, plano-convex, exceedingly variable form, the segments of which are never uniform or regular in arrangement as in *Truncatulina lobaluta* but are more or less evolute in shape and the amount of depression. The surface of the shell is coarsely perforate. Aperture a wide gaping arch extending along the inner margin of the final convolution.

Diameter, 0.56—1 mm.

Horizon and locality.---Miocene; Plum Point, Jones Wharf, Md.

Geological distribution.—Eocene to Recent.

Genus *PULVINULINA* Parker & Jones.

***Pulvinulina elegans*.**

Syn. *Rotalia elegans* d'Orbigny, Ann. Sci. Nat. vol. VII, p. 276, No. 54, 1826.

Pulvinulina elegans Brady, 1884, Rept. Chal., p. 699, pl. cv, figs. 4-6.

Test large, orbicular, both sides convex, but more so upon the inferior side; surface rough, marked especially upon the inferior side by raised tubercles; peripheral margin sharp, slightly carinate. The chambers are arranged in three convolutions which

are all visible upon the superior side and separated by curved band-like septa. Only faint irregular depressions of septal lobes indicate the chambers of the final volution upon the inferior surface. The septal lobes are not curved as upon the superior side; aperture variable and sometimes invisible. Some forms show a very small semi-lunar arch upon the lower surface.

Diam., 0.52--0.65 mm.

This little *Pulvinulina* is the most common form to be found in the Eocene of Pamunkey river and shows great variation in size and form.

Some specimens are plano-convex while others are distinctly bi-convex. Transverse sections show the same nummuline lamination as shown in figure 21 (woodcut, of the Challenger Report. The Jurassic *Epistomina* of Dr. Uhlig (Jahrb. k. k. Geol. Reichsanstalt, vol. xxiii, p. 770, pl. vii, fig. 10 and pl. viii, figs. 1—3,) are very similar to our specimens but the aperture does not appear to be the same. According to Professor Brady this species is almost identical with *Pulvinulina partschiana* d'Orbigny for he states that "The *Rotalia elegans* of the 'Tableau Methodique, founded upon figures in Soldani's 'Testaceographia' passes by insensible gradations into the *Rotalina partschiana* of the Vienna Basin memoir. The particular variety represented by the former figure attains larger dimensions, the test is less convex and therefore relatively thinner, and the septa are marked by broad, clear lines, neither elevated nor depressed, whilst in the latter the sutures, especially on the inferior face, are generally more or less limbate externally."

This author further states that *Pulvinulina elegans* occurs in comparatively shallow water while *Pulvinulina partschiana* is a deep water form.

Horizon and locality.—Eocene; Pamunkey river, Va.

Geological distribution.—Jurassic to Recent.

***Pulvinulina schreibersii*.**

Syn. *Rotalina schreibersii* d'Orbigny, 1846, Foram. Foss. Vien., p. 154, pl. vii, figs. 4—6.

Pulvinulina schreibersii Baggs, Johns Hopkins Univ. Circulars, vol. xv, p. 5, 1895.

Test orbicular, superior side more convex than inferior; consisting of about seven chambers in final convolution, (some speci-

mens show nine); inferior side distinctly stellate with depressed septal lines and elevated chambers, the latter feature being characteristic for the species, and distinguishing it from *Pulvinulina karsteni* by lack of peripheral keel. The final chamber is larger and more globose than the one adjoining; umbilicus depressed on inferior side; aperture a submarginal slit.

Diameter, 0.4—0.54.

This species is not uncommon in the Eocene of Woodstock but seems to be quite rare in the Miocene of James river, Va.

Professor Brady does not mention this species as occurring back of the Miocene but states that it is common in the late Tertiaries of Europe.

Horizon and locality.—Eocene; Woodstock, Va.: Miocene; James river, Va.

Geological distribution.—Eocene to Recent.

Genus *ROTALIA* Lamarck.

***Rotalia beccarii*.**

Syn. *Nautilus beccarii* Linne, 1767, Syst. Nat., Ed. 12, p. 1162; 1788, ibid. Ed. (Gmelin's) 13, p. 3370, No. 4.

Rotalia beccarii Williamson, 1858, Rec. Foram. Gt. Brit., p. 48, pl. iv. figs. 90—92.

Rotalia beccarii Parker & Jones, Phil. Trans., vol. clv, p. 388, pl. xvi, figs. 29, 30, 1865.

Test finely porous, formed of a nearly circular low turbinoid spire, peripheral margin lobulated, obtusely rounded; chambers numerous, ten to forty, somewhat inflated, about ten in the final convolution, and separated by depressed nearly straight septal lines. Convolutions about three, inferior surface thickened, and often beaded with exogenous granules at the umbilicus. Aperture a notched, subdivided opening or a series of pores at the inner margin of the ultimate chamber.

Diameter 0.34—0.74 mm.

The above species is a shallow water form and is rather common in the Pleistocene formation at Cornfield Harbor.

Horizon and locality.—Miocene; Darlington, S. C.: Pleistocene; Cornfield Harbor, Md.

Geological distribution.—Miocene to Recent.

***Rotalia orbicularis*.**

Syn. *Rotalia (Gyroidina) orbicularis* d'Orbigny, Ann. Sci. Nat., vol. VII, p. 278, No. 1;—Modele, No. 13, 1826.

Rotalia orbicularis Terquem, Mem. Soc. Geol. France, ser. 3, vol.

II, Mem. III, p. 60, pl. iv, figs. 1—3, 1882.

Test orbicular, plano-convex or nearly so, superior side being flat, the inferior highly convex and deeply excavated at the umbilicus; peripheral margin subangular, segments numerous separated by curved septa upon the superior side, consisting of three or more convolutions, the inferior side consisting of elevated segments showing a somewhat lobulated margin and with depressed septa.

Professor Brady says of this species "It is isomorphous with *Truncatulina lobatula* in the *Planorbuline* series, and forms a connecting link between *Rotalia beccarii* and *Rotalia soldanii*."

Horizon and locality.—Miocene; Norfolk, Va.; 685 ft.

Geological distribution.—Eocene to Recent.

***Rotalia soldanii*.**

Syn. *Rotalia* (*Gyroidina*) *soldanii* d'Orbigny, Ann. Sci. Nat., vol. vii, p. 278, No. 5;—Modele, No. 36, 1826.

Rotalia soldanii Hantken, 1875, Mittheil. Jahrb. d. k. ung. geol. Anstalt, p. 80, pl. ix, fig. 7, a—c.

Test plano-convex or nearly so, circular, and with slightly lobulated periphery, superior side showing numerous curved septa, inferior much vaulted, with approximately straight septa which are excavated at the umbilicus.

"The plano-convex habit of growth reaches its extreme development, so far as the present genus is concerned, in *Rotalia soldanii*, the test of which resembles that of *Rotalia orbicularis*, except that the convexity of the inferior side is considerably greater. The species corresponds morphologically to *Truncatulina refulgens* and *Pulvinulina micheliniana*, but the shell is more neatly and compactly built, the outline is more rounded, and the walls more finely perforated than in either of the latter species. Sections of the test show that the septal walls are double, and that there is a considerable deposit of shell-substance in the region of the umbilicus, but without any trace of canals." (Chal. Rept., vol. ix, p. 706.)

Horizon and locality—Miocene; Norfolk, Va. Well boring, depth, 645 ft.

Geological distribution.—Cretaceous; Miocene to Recent.

Genus *NONIONINA* d'Orbigny.

***Nonionina affinis*,**

Syn. *Nonionina affinis* Reuss, Sitz. Ak. Wiss. Wien., vol. III, p. 72,

pl. v, fig. 32, 1851.

Nonionina affinis Baggs, Johns Hopkins Univ. Circulars, vol. xv, p. 5, 1895.

Test small, orbicular, strongly compressed, umbilicate, finely perforate; chambers ten to twelve, small, flat, slightly curved, separated by fairly distinct band-like septal lines; septal plane of ultimate chamber somewhat higher than broad and quite large; aperture short, semilunar.

Diameter, 0.32 mm.

Professor Reuss' figure agrees quite well with our specimen but there are twelve chambers visible in the last volution. According to Reuss this species is closely related to *Nonionina punctata* d'Orbigny, but the latter species is thicker in transverse section.

Horizon and locality.—Eocene; Woodstock, Va.

Geological distribution.—Cretaceous and Tertiary.

***Nonionina boueana*.**

Syn. *Nonionina boueana* d'Orbigny, 1846, Foram. Foss. Vien., p. 108, pl. v, figs. 11, 12.

Nonionina boueana Brady, Chal. Rept., vol. ix, p. 729, pl. cix, figs. 12, 13, 1884.

Test broadly oval, strongly compressed laterally, peripheral margin sharp angled, segments numerous, usually about ten or twelve in the last volution, long, narrow, with slight lobulated margin separated by distinct septa somewhat curved especially toward the younger chambers; umbilicus depressed; separated from *Nonionina scapha* by its sharp peripheral margin and more numerous chambers. Aperture a small, arched opening on the inner margin of the septal plane.

Horizon and locality.—Miocene; Norfolk, Va. Well boring, depth, 645 feet.

Geological distribution.—Upper Oligocene to Recent.

***Nonionina depressula*.**

Syn. *Nautilus depressulus* Walker & Jacob, 1798, Adams' Essays Microsc., Kanmacher's Ed., p. 641, pl. xiv, fig. 33.

Nonionina depressula Brady, Chal. Rept., vol. ix, p. 725, pl. civ, fig. 6, 7, 1884.

Nonionina depressula Baggs, Johns Hopkins Univ. Circulars, vol. xv, p. 5, 1895.

Test strongly depressed, convolute, peripheral edge round; chambers numerous, ten to twelve in the last volution, slightly curved septa; septal lines distinct and but faintly depressed, becoming more nearly straight as they approach the ultimate chamber. Umbilical area granulated, nearly flush with the general surface of the shell. Shell-wall thin and hyaline. Aperture a narrow elongated slit.

Diameter, 0.26 to 0.34 mm.

Professor Brady considers this shallow water form as a starved variety of its allies the home of which is in water of less than fifty fathoms, and whose distribution is almost universal.

Horizon and locality.—Eocene; Pamunkey river, Va.: Miocene; Yorktown, Va.

Geological distribution.—Eocene to Recent.

Nonionina scapha.

Syn. *Nautilus scapha* Fichtel & Moll, 1803, Test. Micr., p. 105, pl. xix, figs. d-f.

Nonionina scapha Brady, Chal. Rept., vol. ix, p. 730, pl. cix, figs. 14, 15, and 16?, 1884.

Test free, hyaline, finely perforate, elongate, rather strongly compressed, peripheral margin broadly rounded, chambers numerous, narrow and long, rapidly increasing in size toward the ultimate chamber and separated by nearly straight septal lines which are only slightly depressed. The ultimate chamber is the largest and longest, extending fully two-thirds the length of the shell. The septal plane is broadly oval or somewhat cordate; convolutions about three; twelve to fourteen chambers in the last volution, aperture a small concentric shaped median slit at the inner margin of the final segment.

Length, 0.39—0.65 mm.

Breadth, 0.3—0.47 mm.

This a common form in the Miocene.

Horizon and locality.—Miocene; James river, Yorktown, Va. Plum Point, Md.

Geological distribution.—Miocene to Recent.

Polystomella striatopunctata.

Syn. *Nautilus striatopunctata* Fichtel & Moll, 1803, Test. Micr., p. 61, pl. iv, figs. a-c.

Polystomella striatopunctata Brady, Chal. Rept., vol. ix, p. 733, pl. cix, figs. 22, 23.

Test rounded, both sides equally compressed, peripheral margin obliquely rounded, becoming somewhat lobulated near the ultimate chamber; segments triangular, ten in the last volution, separated by straight, slightly depressed septal lines which are in the shape of bridges marking the retral process of the shell; umbilicus very slightly depressed, septal plane nearly round, aperture in the form of a series of pores or openings along the inner margin of the ultimate segment.

Diameter, 0.26--0.78 mm.

Horizon and locality.—Pleistocene; Cornfield Harbor, Md.

Geological distribution.—This beautiful little *Polystomella* of variable size is the most abundant species in the Pleistocene deposit at Cornfield Harbor.

Genus *AMPHISTEGINA* d'Orbigny.

Amphistegina lessonii.

Syn. *Amphistegina lessonii* d'Orbigny, (parte) Ann. Sci. Nat., vol. VII. p. 304, No. 3, pl. xvii, figs. 1-4, 1826.

Amphistegina lessonii Brady, Chal. Rept., vol. ix, p. 740, pl. cxii, figs. 1-7, 1884.

Amphistegina lessonii Bagg, Johns Hopkins Univ. Circulars, vol. xv, p. 5, 1895.

Test circular, compressed, transverse section elliptical; superior side only slightly more elevated than the inferior; superior surface shows about eighteen angular segments; inferior surface less distinctly chambered, more irregular; chambers narrow, angular, visible in transmitted light; surface smooth, of a brownish yellow color.

Diameter, 1.47--2 mm.

According to Professor Brady this species shows great variation in the amount of convexity. Our specimens agree more closely with his figure 4 of plate cvi, in the Challenger Report and may be considered typical for the species.

This is not a common form and only three specimens have been obtained on Potomac creek, and only a few are found in the Miocene of Darlington, nearly all of which are broken.

Horizon and locality.—Eocene; Woodstock, Va.: Miocene; Darlington, S. C.

Geological distribution.—Eocene to Recent.

Summary of Results.

The difference in size between the Cretaceous and Tertiary Foraminifera is very marked, scarcely any of the latter approaching the former in size. Whether this difference is due to the unfavorable conditions for foraminiferal life or because of a difference in the forms of the Foraminifera is not altogether clear; but it seems quite probable that it is due to the greater amount of muddy sediment which is found in the Tertiary beds as compared with the almost pure greensands of the Atlantic Cretaceous.

This difference in sediment points to more shallow water in Tertiary than in Cretaceous time. Greensand at the present day is being deposited at moderate depths in the Gulf of Mexico as was shown by Pourtales. From the investigations of Murray and Renard and others it is sufficiently proven that the production of glauconite seldom takes place at depths greater than 900 fathoms, and generally occurs from 100 to 200 fathoms. This is necessarily the case since usually the greater depths are found too far from the land to allow inorganic materials to reach the place where glauconite would otherwise be deposited, and it has been shown that this inorganic matter is essential for the formation of glauconite. This difference in depth is further substantiated in the Eocene by the great abundance of the shallow water form, *Pulvinulina elegans*; and the absence of its relative, *Pulvinulina partschiana*, which is regarded as a deep water species.

Among the most characteristic genera of the forms identified as belonging particularly to the Eocene may be mentioned *Amphistegina*. The genus *Nodosaria* is represented by only five species none of which are abundant. Cristellarians are also apparently very scarce in the Eocene while the genus *Polymorphina* has a wide representation. The genus *Cyclammina* is of exceptional interest inasmuch as it is considered by Prof. H. B. Brady to be unknown in the fossil state, but that it occurs in beds of Miocene age in New Jersey is proved beyond question by the author who has given the specimens a careful and thorough study.

The shell is finely *arenaceo-siliceous* and hence is unaffected by acids. Its structure is peculiar and quite complex which, together

with its large size and flattened form, make the genus easily recognizable.

The following species belonging to the Eocene occur also in the Cretaceous of New Jersey.

Nodosaria communis d'Orbigny.

Nodosaria consobrina var. *emaciata* Reuss.

Nodosaria farcimen Soldani.

Vaginulina legumen Linné.

Polymorphina communis d'Orbigny.

Polymorphina compressa d'Orbigny.

Globigerina bulloides d'Orbigny.

Discorbina bertheloti d'Orbigny.

Among the Miocene species are quite a number which are common to the Cretaceous. These are:

Textularia agglutinans d'Orbigny.

Textularia gramen d'Orbigny.

Textularia sagittula DeFrance.

Lagena globosa Montagu.

Nodosaria obliqua Linné; and also those in the Eocene.

Cristellaria cultrata Montfort.

Cristellaria wetherellii Jones.

Cristellaria rotulata Lam.

Polymorphina communis d'Orbigny.

Polymorphina compressa d'Orbigny.

Polymorphina gibba d'Orbigny.

Polymorphina lactea Walker & Jacob.

Globigerina bulloides d'Orbigny.

Discorbina bertheloti d'Orbigny.

Truncatulina haidingerii d'Orbigny.

Truncatulina lobatula Walker & Jacob.

Pelagic species.

One of the subjects brought prominently into notice by the observations taken on the Challenger Expedition is the relation of the surface fauna of the ocean to that of the bottom deposits. So far as the *Foraminifera* are concerned the question is by no means a new one; but the Challenger collections, and those more recently made by Mr. Murray on the cruises of the "Knight Errant" and "Triton", have brought many fresh facts into notice, and furnished new ground for its discussion.

The *Foraminifera* as a rule are not of pelagic habit. On the contrary, by far the larger proportion, probably 98 or 99 per cent. of the known recent "species" or "varieties," including the whole of the porcellaneous and arenaceous groups and the bulk of the hyaline forms, inhabit the sand or mud of the sea bottom, and are endowed with no swimming or floating powers. This may be regarded as a well ascertained fact. But on the other hand, there are a certain number of forms belonging to eight or perhaps nine genera, which it is equally certain pass their existence, either in part or entirely at the surface of the ocean or in mid-water. The practical importance of these comparatively few species is due to the extraordinary abundance in which they are found, and the relatively large proportion of the entire mass of the bottom deposit which is made up of their shells.

	1	2	3	4	5	6	7	8	9	10	11	12
" <i>consobrina</i>												
<i>var emaciata</i>	.	.	.	0	.	.	.	.	.	.	.	.
" <i>farcimen</i>	0	.	.	.	.	.	.	.	.	.	.	.
" <i>obliqua</i>	.	.	.	.	.	.	.	0	.	.	.	.
<i>Vaginulina legumen</i>	.	.	0	.	.	.	.	.	.	.	.	.
<i>Cristellaria cultrata</i>	.	.	.	.	.	.	.	0	.	.	.	.
" <i>radiata</i>	.	0	.	.	.	.	.	.	.	.	.	.
" <i>rotulata</i>	.	.	.	.	.	.	.	.	.	.	.	0
" <i>wetherillii</i> occurs in a well boring at Crisfield, Md.												
<i>Polymorphina amygdaloides</i>	0	.	.	.	.	.	.	.	.	.	.	.
" <i>austriaca</i>	.	0	.	.	.	.	.	.	.	.	.	.
" <i>communis</i>	0	0	.	.	.	.	.	.	0	.	.	.
" <i>complanata</i>	0	.	.	.	.	.	.	.	.	.	.	.
" <i>compressa</i>	.	0	.	.	.	0	.	0	0	0	.	.
" <i>elegantissima</i>	.	0	.	.	.	.	.	.	.	.	.	.
" <i>gibba</i>	.	0	.	.	.	.	.	.	.	.	.	.
" <i>lactea</i>	.	0	.	.	.	.	.	.	0	0	.	.
" <i>prælonga</i>	.	0	.	.	.	.	.	.	.	.	.	.
<i>Uvigerina canariensis</i>	.	.	.	.	.	.	.	0	.	.	.	.
" <i>pygmæa</i>	.	.	.	.	.	.	.	0	.	.	.	.
" <i>tenuistriata</i>	.	.	.	.	.	.	.	0	.	.	.	.
<i>Globigerina bulloides</i>	.	0	.	.	0	0	0	0	0	.	.	.
<i>Spirillina orbicularis</i>	.	.	.	.	.	.	0	.	.	.	.	.
<i>Discorbina berthelotadi</i>	.	0	.	.	.	.	.	.	.	.	.	.
" <i>orbicularis</i>	.	.	.	.	0	.	.	.	.	.	.	.
<i>Truncatulina haidingerii</i>	.	.	.	.	.	.	.	0	.	.	.	.
" <i>lobatula</i>	.	0	.	.	0	0	0	0	0	0	.	.
" <i>variabilis</i>	.	.	.	.	.	.	0	.	0	0	.	.
<i>Pulvinulina elegans</i>	0	.	.	.	.	.	.	.	.	.	.	.
" <i>schreibersii</i>	.	0	.	.	.	0	.	.	.	.	.	.
<i>Rotalia beccarii</i>	.	.	.	.	0	.	.	.	.	.	.	0
" <i>orbicularis</i>	.	.	.	.	.	.	.	0	.	.	.	.
" <i>soldanii</i>	.	.	.	.	.	.	.	0	.	.	.	.
<i>Nonionina affinis</i>	.	0	.	.	.	.	0	.	.	.	.	.
" <i>boueana</i>	.	.	.	.	.	.	.	0	.	.	.	.
" <i>depressula</i>	0	.	.	.	.	.	0	.	.	.	.	.
" <i>scapha</i>	.	.	.	.	.	0	0	0	0	.	.	.
<i>Polystomella striatopunctata</i> ..	.	.	.	.	.	.	.	.	.	.	.	0
<i>Amphistegina lessonii</i>	.	0	.	.	0	.	.	.	.	.	.	.

List of Species Described in this Paper

Amphistegina lessonii d'Orb., p. 42, pl. 1, fig. 6; *Bulimina aculeata* d'Orb., p. 21; *B. buchiana* d'Orb., p. 21, pl. 2, fig. 4; *B. elongata* d'Orb., p. 22; *Cristellaria cultrata* (Montfort), 26; *C. radiata* Reuss, p. 27, pl. 1, fig. 3; *C. rotulata*, (Lam.), p. 27; *C. wetherellii* (Jones), p. 27; *Cyclamina placenta* Reuss, p. 18; *Discorbina bertheloti*, d'Orb., p. 34; *D. orbicularis* (Terquem), p. 34; *Globigerina bulloides* d'Orb., p. 33; *Lagena globosa* (Montagu), 23; *Miliolina seminulum* (Linné), p. 23; *Nodosaria aculeata* d'Orb., p. 24; *N. affinis* d'Orb., p. 24; *N. bacillum* Defr., p. 24; *N. communis* d'Orb., p. 25; *N. consobrina* var. *emaciata* Reuss, p. 25; *N. farcimen* (Soldani), p. 25, pl. 1, fig. 2; *N. obliqua* (Linné), p. 26; *Nonionina affinis* Reuss, p. 39, pl. 1, fig. 5; *N. boueana* d'Orb., p. 40; *N. depressula* (Walker & Jacob), p. 40; *N. scapha* (Fichtel & Moll), p. 41, pl. 3, fig. 4; *Polymorphina amygdaloides* Reuss, p. 28; *P. austriaca* d'Orb., p. 28; *P. communis* d'Orb., p. 29; *P. complanata* d'Orb., p. 29; *P. compressa* d'Orb., p. 29, pl. 3, fig. 1; *P. elegantissima* Parker & Jones, p. 30; *P. gibba* Walker & Jacob, p. 30; *P. lactea* (Walker & Jacob), p. 31; *P. praelonga* Terquem, p. 31; *Polystomella striatopunctata* (Fichtel & Moll), p. 41, pl. 2, fig. 6; *Pulvinulina elegans* d'Orb., p. 36, pl. 1, fig. 4; *P. schreibersii* d'Orb., p. 37, pl. 3, fig. 2; *Rotalia beccarii* (Linné), p. 38, pl. 3, fig. 3; *R. orbicularis* d'Orb., p. 38; *R. soldanii* d'Orb., p. 39; *Spirillina orbicularis*, n. sp., p. 33, pl. 2, fig. 2; *Spiroloculina plaunlata* Lam., p. 22; *Spiroplecta clarki* Bagg, p. 20, pl. 1, fig. 1; *Textularia abbreviata* d'Orb., p. 18; *T. agglutinans* d'Orb., p. 19; *T. articulata* d'Orb., p. 19, pl. 2, fig. 1; *T. gramen* d'Orb., p. 19; *T. sagittula* Defr., p. 20; *T. subangulata* d'Orb., p. 20; *Truncatulina haidingerii* (d'Orb.), p. 35; *T. lobata* (Walker & Jacob), p. 35; *T. variabilis* d'Orb., p. 36, pl. 2, fig. 5; *Uvigerina canariensis* d'Orb.; p. 31; *U. pygmæa* d'Orb., p. 32, pl. 2, fig. 3; *U. tenuistriata* Reuss, p. 32; *Vaginulina legumen* (Linné), p. 26.

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N. B.—The preparation of plates for this Bulletin was in some respects an after-thought; in fact they were not completed until most of the press work was done; hence no reference to them will be found in the text. Their number is however so small that little or no inconvenience will be experienced from this omission.—Ed.



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